GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1

Chemical Engineering (CAPD)

Subject Name Advanced Thermodynamics

Sr.No	Course content
1.	REFERIGERATION: Vapour compression cycle, Industrial vapour compression cycle: selection criteria, flow sheet, Calculations of net refrigeration effect, TR, COP, etc Vapour absorption cycles, Industrial vapour absorption cycles: Ammonia vapour absorption cycle, Lithium bromide water vapour absorption cycle, selection criteria, flow sheets, Calculations of net refrigeration effect, TR,COP, steam required, Solvent required,etc, Importance of economizer in refrigeration cycles
2.	CHEMICAL REACTION EQUILIBRIA: Criteria of chemical equilibrium, Equilibrium extent of reaction, Equilibrium constant, Effect of temperature and pressure on K, evaluation of K by various methods. Evaluation of equilibrium extent of reaction for exothermic, endothermic, reversible, irreversible reactions and various combinations. Thermodynamic analysis of some important industrial reactions. liquid phase and heterogeneous reactions, multireaction equilibria, simultaneous, consecutive reactions and various combinations, adiabatic reactions.
3.	VAPOUR-LIQUID EQUILIBRIUM: Non ideal system, evaluations of activity coefficient and fugacity coefficient, dew point and bubble point calculations, BUBLP, DEWP, BUBLT and DEWT Calculations, P-T Flash calculations, Adiabatic Flash calculations, Block diagrams of these calculations
4.	LIQUID-LIQUID EQUILIBRIUM: Criteria of equilibrium, Different types of liquid-liquid solubility diagram, evaluation of LLE data
5.	VAPOUR-LIQUID-LIQUID EQUILIBRIUM: Criteria of VLLE, Txy diagram of VLLE at constant pressure and for several pressures, Pxy diagram at constant temperature

Reference Books:

1. Smith J.M, Van Ness H.C., Abbott M. M, "Introduction to Chemical Engineering Thermodynamics", The McGraw Hill Companies, Inc., USA, 7th Ed., 2005.
2. Elliot J. R. and Lira C.T, "Introductory Chemical Engineering Thermodynamics ", Prentice Hall, 1999.
3. Hougen O.A., Watson K.M., and Ragatz R.A. , "Chemical Process Principles Part-II" Thermodynamics, John Wiley 1970
4. Perry's chemical engineers handbook,7th edition, McGraw-Hill, USA,2000.
5. Elliot J. R. and Lira C.T, "Introductory Chemical Engineering Thermodynamics ", Prentice Hall, 1999

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Semester: 1

Chemical Engineering (CAPD)

Subject Name Advanced Computational Techniques for Research

Sr.No	Course content (List of Experiments to be performed on)
1.	Algebraic Equation Solver.
2.	Differential Algebraic Equation Solver (DAE).
3.	Partial Differential Equation Solver (PDE).
4.	Use of Fortran Solver in C/C++ Environment.
5.	Mat lab/ MathCAD for solution of set of equation/ Algebraic Equation/ Differential Algebraic Equation/ Partial Differential Equation
6.	Genetic Algorithm.
7.	Artificial Neural network
8.	Simulated Annealing.
9.	Data reconciliation.
10.	Solution of Algebraic Equation using Optimization methods like Pattern Search, Box Complex etc.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1
Chemical Engineering (CAPD)

Subject Name Advanced Kinetics and Reaction Engineering

Sr.No	Course content
1.	INTRODUCTION Introduction to design for Heterogeneous Reacting Systems, Linear rate expressions, Non-linear rate expressions
2.	HETROGENEOUS REACTIONS Fluid-Particle Reactions, Different Types of Models, Fluid-Fluid Reactions, Rate equation, Kinetic regimes for mass transfer & reaction, Rate equation for Different Kinetic regimes.
3.	FLUIDISED BED REACTORS Design of catalytic Reactors, Fluidized bed reactor Reaction kinetics, Performance equation, Design equation for fluidized bed reactor, Different Models for fluidized bed reactor, Hydrodynamic flow model, Bubbling Fluidized bed reactor, Flow patterns, Performance equation.
4.	MULTIPHASE REACTORS Design of Multiphase Reactor, Slurry Reactor-Slurry Reaction kinetics, Performance equation, Applications. Loop Reactor- Introduction, and Field Applications, Practical limitation of Stirred Tank and Loop Reactor, Design Methods, Residence Time Distribution, Reactor Modeling. Moving bed reactor- performance equation, characteristics, application etc
5.	BUBBLE COLUMN REACTOR Bubble column Reactor-Introduction, Various factors affecting the performance of Bubble column Reactor, Industrial Applications, Advantages and disadvantages of Bubble column reactor, Criteria of selection of different types of gas-liquid reactors, Process design of Bubble column reactor, Example of Bubble column reactor
6.	DESIGN OF REACTORS Bio-Reactor- Introduction, Rate law, Stoichiometry, Mass-Balance, Design equation Moving Bed Reactor- Introduction, Kinetics of Moving Bed Reactor, Performance equation, Example, Trickle Bed Reactor-Introduction, Design, Flow Regimes, Liquid Hold up, Pressure Drop, Mass Transfer
7.	MONOLITHIC REACTORS Introduction, types, classifications, characteristics, applications, advantages etc

Reference Books:

1. Chemical Reaction Engineering by Octave Levenspiel.
2. Elements of Chemical Reaction Engineering by H.Scott Fogler.
3. Introduction to Process Engineering and design by S.B.Thakore & B.I. Bhatt
4. Ulmann's Encyclopedia Vol-4.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1
Chemical Engineering (CAPD)

Subject Name Computerized Process Control

Sr.No	Course content
1.	Industrial Automation: Overview, Introduction, Aims of plant automation, Computer-based plant automation concepts, Distributed computer control
2.	Computers and Interfacing: Introduction to Computers, Computer interfacing for data acquisition and control, Data acquisition and control by using std. add-on-cards
3.	The Control of Chemical Process: Characteristics and Associated Problems, Incentives for chemical process control, Design aspects and Hardware for a process control system.
4.	Distributed Digital Control Systems : Advantages of DCC, Process control requirements of computers, Computer network - multi-mini computer architecture, peer-to-peer and server based networks, network topology, network adapter card, software; Selection of a suitable DICS, Interconnection of networks, Communication in distributed control systems, Logical topology, Ethernet card, Selection of operator interface, ERP and process control
5.	Examples of Experimental Computer Control of Processes: Computer Control of liquid level system, a heat exchanger, a fed batch fermentor, Temperature Control for plastic injection molding processes, On-line optimizing control of a distillation column.
6.	Control System: Dynamic Behavior First Order Control Systems, Multicapacity Control Systems, Analysis of Dynamic Behavior of Second Order Control Systems.
7.	Mechanism of Control System and controllers : Block Diagram Algebra, Mechanism of Controllers and Control Valve, Dynamic Behavior of Controllers.
8.	Stability Analysis of Control Systems : Stability for linear system, Routh-Hurwitz stability criterion, Limitations of the Routh test for stability, Root Locus diagram, Method of plotting the Root Locus diagram for negative feedback system.
9.	Design of Control Systems using Frequency Response : Frequency response of a first order system, Bode diagram, Bode diagram of first order system, First order systems in series, Bode diagram of second order system, Proportional controller; Bode diagrams for proportional derivative controller, proportional integral controller, proportional- integral-derivative controller & transportation lag

	parameter; The stability criterion, Phase and gain margins, Ziegler-Nichols optimum controller settings, Limitations of the Ziegler-Nichols method.
10.	Concepts of Measurement and Measuring Instruments : Introduction, System configuration, Problem analysis, Basic characteristics of measuring devices, Calibration, Transducers and various Measuring Instruments for Process Control

Experiments, Exercise and calculations based on above topics.

Reference Books:

1. Process Control Instrumentation Technology : Curtis Johnson, Prentice Hall India Pvt. Ltd.
2. Process Control and Instrumentation : Prof. R. P. Vyas, Central Techno Publications, Nagpur
3. Chemical Process Control: George Stephanopoulos, Prentice Hall India Pvt. Ltd.
4. Instrumentation Devices and Systems : C S Rangan, G R Sarma, V S V Mani; Tata McGrawhill
5. Computer Control of Processes : M. Chidambaram, Narosa Publishing House
6. Process Instrumentation and Control : A. P. Kulkarni, Nirali Prakashan
7. Industrial Instrumentation : Donald P. Ekman

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Chemical Process Optimization

Sr.No	Course content
1.	Optimization: Basic concept of optimization, Mathematical formulation of optimization problems; Classification of Optimization Problems - single variable problems, Multivariable problems without constraints, Multivariable problems with constraints, Maximization and minimization problems, Convex and concave functions, Necessary and sufficient conditions for stationary points
2.	Optimization of Unconstrained Functions One-Dimensional Search: analytical methods, Numerical methods, scanning and bracketing techniques, region elimination techniques, examples.
3.	Multivariable Search – Analytical Methods: classification, stationary points, direct substitution, constrained variation, penalty function, Lagrangian Multiplier, Kuhn-Tucker theorem, Simplex Method of Linear Programming, Duals in optimization, Quadratic programming, Geometric Programming.
4.	Multivariable Search – Numerical Methods: general principles of numerical search, direction of search, final stage in search, direct search, pattern search, acceleration in direct search, gradient methods, the complex method of Box,
5.	Non- Linear Programming With Constrained And Its Applications: Quadratic programming, Generalized reduced gradients methods, Successive linear and successive quadratic programming, Dynamic programming, Integer and mixed integer programming.
6.	Application of Optimization In Chemical Engineering: Optimization of staged and discrete processes, Optimal shell-tube heat exchanger design, Optimal pipe diameter, Optimal design of an Ammonia reactor.
7.	Nontraditional Optimization Techniques: Statistical Optimization Techniques - Genetic Algorithm, Simulated Annealing, Ant Colony Optimization, TABU search, Multi Objective Optimization.

Reference Books:

1. Optimization in Chemical processes
   Edgar, Himmeiblau, Lasdon, by McGrawHill Publication
2. Optimization Theory and Practice
   Gordon S.G. Beveridge and Robert S. Schechter, by McGrawHill Publication
3. Engineering Optimization –Theory and Practice
   Singiresu S.Rao, Published by New Age International publishers
4. Product and Process Design Principles
   Warren D Seider, J. D. Seader, Daniel R Lewin, by John Wiley and Sons,Inc.
5. Systematic Methods of Chemical Process Design
   Lorens T. Biegler , E.Ignacio grossmann, Arthur W Westerberg , byPHI
6. Engineering Optimization Methods and Applications
   Rekllaities F. V., Ravindan A. and Ragsdell K. M., John Willy, New York, 1983.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Industrial Biotechnology

Sr.No	Course content
1.	INTRODUCTION TO INDUSTRIAL BIOPROCESS: Introduction to fermentation process - definition, scope, history, microorganisms and industrial products - Screening for microbes of industrial importance - Isolation and preservation of industrial micro organisms.
2.	STRAIN IMPROVEMENT AND MEDIA PREPARATION: Environmental factors and genetic factors for improvement - Immobilization methods - Types of carriers - advantages and disadvantages - Inoculums media and inoculums preparation - Medium requirements for fermentation process.
3.	FERMENTATION PROCESS: Types of fermentation processes - Solid state, surface and submerged fermentations - batch, fed batch, continuous fermentations – Directdual or multiple fermentations - Scale up of fermentations
4.	PRODUCTION OF PRIMARY AND SECONDARY METABOLITES: Fermentative production of industrial alcohol, beer - Principles of wine making -Fermentative production of citric acid, vitamin B12, glutamic acid - Antibiotics, commercial production of benzyl penicillin and tetracyclines.
5.	PRODUCTION OF MODERN BIOTECHNOLOGICAL PRODUCTS :Production and application of microbial enzymes - Amylases, lipases and proteases - Steroid transformations - Microbial biopesticides and biofertilizers - Principles of vaccine production and types of vaccines

Experiments, Exercise and calculations based on above topics.

Reference Books:

1. Casida, J.R., L.E., Industrial Microbiology, Willey Eastern Ltd, New Delhi,1stEdition, 2006
2. Wulf Cruger and Anneliese Cruger., Biotechnoloogy, (A text book of industrial Microbiology), Panima Publishers, New Delhi, 2ndedition, 2003
3. Prescott and Dunn, Industrial Microbiology, CBS Publishers, New Delhi, 4th Edition, 1987
4. Young, M.Y., Comprehensive Biotechnology Vol. 1-4, Pergamon Press, Oxford, 1st Edition, 1985
5. Stanbury, P.F., and Whitaker, A., Principles of Fermentation Technology, 2nd Edition, Pergamon Press, Oxford, 2005.

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Semester: 1I

Chemical Engineering (CAPD)

Subject Name Process Plant Simulation

Sr.No	Course content
	Experiment to be performed on process plant simulation software like Chemcad, Hysis, Aspun, Design-II, Enviropro design for steady state & dynamic simulation.
	Steady State Simulation:
1.	Simulation of Stream mixing & splitting.
2.	Simulation of decanter, Pump, Valve.
3.	Simulation of Distillation, Adsorption, Heat exchanger, Liquid-Liquid Extraction, Reactors, Dryer.
4.	Flash Calculation
5.	Material & Energy balance for manufacturing process flow sheet.
6.	Debottlenecking & Set point Optimization study for process plant.
	Dynamic Simulation :
7.	Batch Distillation Simulation.
8.	Batch Reactor Simulation
9.	Batch Dryer Simulation.
10.	Pressure Level & Flow Controller

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1
Chemical Engineering (CAPD)

Subject Name Energy and Mass Integration (Major Elective -I)

Sr.No	Course content
1.	Heat and Power Integration: Introduction, basic heat exchanger network synthesis(HENS), Hohmann / Lochart Composite Curves, Grand Composite Curve(GCC), pinch design approach to inventing a network, Picking the right minimum temperature driving force ΔTMIN
2.	Synthesis of Heat Exchanger Networks: Minimum utility cost, maximum energy recovery, minimum number of exchanger, threshold and optimum approach temperature, derivation of network structures for minimization of annual costs, , Multiple utility design problems.
3.	Optimization and Heat Integration: Sequential and Simultaneous approaches of Optimization and Integration, Simultaneous MINLP model for optimization, Application, Problems and Examples – Crude Heat Pre-train, Aromatics Plants, Evaporator / Dryer Plant.
4.	Refrigeration Cycles: Design of refrigeration cycles, Grand Composite Curves to design refrigeration cycles, optimization of refrigeration cycle design.
5.	Energy Integrated Distillation Processes: Heat flows in distillation, T-Q Diagram, Interheating / Intercooling, Thermal condition of feed, Heat flows in side strippers and side enriches Heat integrated distillation trains, impact of pressure, multi effect distillation, Heat Pumping Vapour Recompression and Reboiler Flashing, Heat engine and Heat Pumps optimization.
6.	Mass Integration: Introduction, minimum Mass Separating Agent (MSA), mass exchanger networks minimum external MSA, minimum number of mass exchangers.

Reference Books:

1. Systematic Methods of Chemical Process Design
   Lorens T. Biegler , E.Ignacio grossmann, Arthur W Westerberg
   Published by-Prentice Hall International,Inc
2. Product and Process Design Principles
   Warren D Seider, J. D. Seader, Daniel R Lewin
   Published by John Wiley and Sons,Inc.
3. User Guide on Process Integration for the efficient use of energy
   B Linnhoff IChE (UK)

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Property Prediction for Mixtures (Major Elective-2)

Sr.No	Course content
1.	Estimation and Computation of Thermodynamic and Transport Properties: Estimation of Properties - Density, Viscosity, Thermal conductivity, Enthalpy, K-value, Diffusivity, Surface Tension, Types of Estimations, estimation of pure component constants, Mixing rules.
2.	Density: Densities of Gas using equations of state, estimation of liquid densities by HBT method, Rackett techniques, Bhirud method, densities of liquid mixtures, effect of temperature and pressure.
3.	Fluid Phase Equilibrium Prosperities: Thermodynamics of VLE, fugacity and activity coefficients, binary VLE, multi-component VLE, solubility of gases in liquids, liquid-liquid equilibrium.
4.	Heat Capacity and Enthalpy: Fundamental thermodynamic relations, departure functions, heat capacity of gases and liquids, enthalpy of vaporization, estimation of boiling point
5.	Viscosity: Theory of gas transport properties, estimation of low-pressure viscosity for pure gas and mixture, effect of pressure, viscosity at high pressure, liquid viscosity, effect of temp and pressure on liquid viscosity, liquid mixture viscosity.
6.	Thermal Conductivity: Theory of thermal conductivity, thermal conductivity of poly atomic Gases, effect of temperature and pressure, thermal conductivity of liquids, estimation of thermal conductivity for pure liquids and liquid mixtures
7.	Diffusion Coefficient: Diffusion coefficient for binary Gas systems, effect of temperature and pressure, diffusion in multi-component gas, estimation of liquid diffusivity, effect of concentration and temperature, diffusion in multi-component liquid mixtures and in electrolytes.
8.	Surface Tension: Estimation of the surface tension for pure liquids, effect of temperature, surface tension of aqueous and non-aqueous solutions.
9.	Selection of thermodynamic Model/Method: Selection of best proper property prediction method for available data, limitations and advantages of methods, data sources, computer database / programs for property estimation.

Reference Books:

1.The Properties of Gases & Liquids,
Robert C Reid, John M Prausnitz and Bruce E. Poling by MaGraw-Hill
2.Perry's Chemical Engineers' Handbook,
Perry, R.H.; Green, D.W. by McGraw-Hill

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Chemical System Modeling and Simulation (Major Elective – 3)

Sr.No	Course content
1.	Modeling Aspects: Deterministic Versus Stochastic Process, Deterministic Process, Stochastic Process, Physical Modeling, Mathematical Modelling
2.	Classification of Mathematical Modeling: Independent and Dependent Variables, and Parameters, Classification based on Variation of Independent Variables, Distributed parameter Models, Lumped Parameter Models, Classification based on the State of the Process, Static Model, Dynamic Model, The complete Mathematical Model, Classification Based on the Type of the Process, Rigid or Deterministic Models, Stochastic or Probabilistic Models, Comparison between Rigid and Stochastic Model.
3.	Models in Mass-Transfer Operations: Steady–state Single–stage Solvent Extraction, Steady-state Two–stage Solvent Extraction, Steady-state N–stage Counter-current Solvent Extraction
4.	Models in Heat –transfer Operations: Counter current Cooling of Tanks, Temperature Distribution in a Transverse Cooling fin of Triangular Cross-Section, Unsteady-state heat Transfer in a Tubular Gas Pre heater, Heat loss through pipe flanges.
5.	Models in Fluid-flow Operations: Laminar flow in a Narrow slit, The Continuity Equation, Concentration Profile and Temperature of fixed bed catalytic Reactor.
	Simulation:
6.	Modular Approaches & Equation: Modular Approaches to process simulation, The Equation solving approach
7.	Decomposition of networks: Tearing algorithms, Algorithms based on the signal flow graph, Algorithms based on reduced diagraph.
8.	Convergence promotion and physical and thermodynamic properties: Convergence promotion., Physical and thermodynamic properties
9.	Professional simulation packages

Experiments, Exercise and calculations based on above topics.

Reference Books:

1. Applied Mathematics in Chemical engg---- Mickley, Sherwood & Reed.
2. Mathematical methods in Chemical engg---- Jenson & Jeffereys
3. Process Plant Simulation --- B.V.Babu
4. Systematic Methods of Chemical Process Design, Lorens T. Biegler , E.Ignacio grossmann, Arthur W Westerberg, Prentice Hall International,Inc
5. Process Modeling and Simulation by Lyuben

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1
Chemical Engineering (CAPD)

Subject Name Cleaner Production in Chemical Industries (Inter Disciplinary- I)

Sr.No	Course content
1.	Introduction to Cleaner Technology (CT), Technology adoption for Cleaner Production (CP).
2.	Role of C.P. in survival and sustainable development of Chemical Industries.
3.	Cleaner Production: The basis, necessity and potential.
4.	C.P. tools, techniques, methodology and applications.
5.	Overview of Good House Keeping, Process Modification / Changes, Process Technology Innovations, Equipment Modification, Reuse and Recycle.
6.	Principles and Concepts of Green Chemistry, Thermodynamics and Reaction Engineering Principles for C.P., Role of Environmental Biotechnology in C.P.
7.	Use of Unit Operations – Adsorption, Absorption and Extraction in C.P.
8.	Energy Audit and Energy Conservation, C.P. & C.T. and energy efficiency integration, Energy conservation via Cleaner Technology Options, Use of clean fuels inclusive of H2 as a clean fuel of tomorrow. C.P. Options with special reference to Energy Conservation in Thermal Power Plants.
9.	C.P. & C.T. as Remedial Measures for Mitigating Climate Change, Ozone layer depletion and current practices to avoid depletion.
10.	Resource recovery / by product recovery from manufacturing process by Cleaner Production Technology (CPT) with special reference to Small Scale Industries.
11.	Industrial waste minimization and Waste Minimization Circles.
12.	Hazard Prevention by C.P. Technology Alternatives.
13.	Designing Cleaner Production – Green Processes
14.	Cleaner Production and Cleaner Technology implementation
15.	Typical case studies w.r.t. Petrochemicals and Polymers, Chlor-alkali industries, Dyes & Intermediates, Bulk drug and Pharmaceuticals, Distilleries and Sugar industries, Pesticide Manufacture, Cement Manufacture, Textile industries, Electroplating Units, Specialty Chemicals inclusive of environmentally benign solvents etc.

Tutorials based on above topics.

Reference Books:

1. Cleaner Production Worldwide, 1993, United Nations Environment Programme, Industry and Environment, Paris, France, 1993
2. Cleaner Production: Training Resource Package, UNEP IE, Paris, 1996
3. Clean Technology for manufacture of Specialty Chemicals, Editor-W. Hoyle and M. Lancaster, Royal Society of Chemistry, U.K.
4. Engineers Guide to Cleaner Production Technologies by Paul M. Randall
5. Green Chemistry : Environmentally Benign Reactions by V. K. Ahluvalia
6. Chemical Process Safety: Learning from case Histories, R. E. Sanders, Oxford Butter Worth Publication.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1
Chemical Engineering (CAPD)

Subject Name Polymer Science & Synthesis of Polymers (Major Elective – I)

Sr.No	Course content
1.	Introduction: Introduction to polymers, Classification of Polymers, Carother's equation.
2.	Natural Polymers Introduction, Miscellaneous natural polymers, Polysaccharides, Proteins, Nucleic acids etc.
3.	Chemistry Of Polymerization Addition and condensation polymerization tech. (bulk, solution, suspension, emulsion, solid phase, gas phase, interfacial, melt polycondensation, plasma, phase transfer etc.).Chain polymerization, free radical mechanism / polymerization. Ionic polymerization / mechanism, group transfer polymerization. Oxidative Polymerization, Step polymerization stoichiometry, gelation and cross linking, polyaddition polymerization, ROP.
4.	Molecular weight and size "Average" Molecular Weight, Number- Average and Weight-Average Molecular Weights, Sedimentation and Viscosity-Average Molecular Weights, Molecular Weight and Degree of Polymerization, Polydispersity and Molecular Weight Distribution in Polymers, The Practical Significance of Polymer Molecular Weight, Size of Polymer Molecules.
5.	Kinetics of Polymerization Introduction, Free-Radical Chain Polymerization, Cationic Polymerization, Anionic Polymerization, Polycondensation.
6.	Chemical and Geometrical Structure of Polymer Molecules. General Remarks on Polymer Microstructure, Microstructures based on the Chemical Structure, Microstructure Based on the Geometrical Structure
7.	Polymer Solutions The process of Polymer dissolution, Thermodynamics of Polymer dissolution, Some solvents and non-solvents for Polymers, Effect of molecular weight on solubility, solubility of crystalline and amorphous polymers, Nature of polymer molecules in solution, Viscosity of dilute polymer solution, Viscosity of concentrated polymer solution
8.	Polymer Degradation Introduction, Types of degradation, Thermal degradation, Mechanical degradation, Photodegradation, Degradation by high energy radiation,

	Degradation by ultrasonic waves, Oxidative degradation, Ozone oxidative degradation, Oxidative degradation of saturated polymers, Oxidation of phenol formaldehyde.
9.	Polymer Reactions Hydrogenation and substitution reactions, Reaction of specific groups like hydroxyl, aldehyde, ketone, carboxyl, amino, vulcanization. Additional reactions, polymers as catalysts, polymers as substrates (Merrifield synthesis etc.) Polymer supported reactions.

Reference Books:

1. Polymer Chemistry an Introduction, Oxford University Press, M.P. Stevens,1991.
2. Principles of Polymerization, Wiley eastern, George Odian, 1991
3. Polymer Science, New age international (P) Ltd. Publishers, V.R. Gowarikar,Pearson publication,2003.
4. Text book of Polymer Science, Wiley Eastern,F.W.BillmeyerJr 2003.
5. Polymer Chemistry by B. K. Sharma.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Polymer Processing (Major Elective-2)

Sr.No	Course content
1.	Introduction to Polymer Processing: Polymer Processing Methods and Machinery, Analysis of Polymer Processing in Terms of Elementary Steps and Shaping Methods.
2.	Mixing: Introduction, Historical, Terminology, mixing requirements with polymeric materials, Place of mixing in polymer processing.
3.	Principles: General, State of admixture, Mechanisms and Kinetics of mixing, Relationships between the nature of the components of a mixture and mixing processes, General aspects of machine design and operation
4.	Blending and Blending Equipment: General Considerations, Vibratory or Reciprocating blenders, Tumble blenders, Stirrer mixers, Intensive non-fluxing mixers, Ribbon blenders and related mixtures, Z-blade and related double-arm mixers, Plough mixers, Air and fluidized bed mixers, toroidal mixers, Buss continuous turbine mixer, Colloid, disc and pin mills etc., Bead mills etc., Mullers and pug mills, Roll mills, Electrostatic blending etc.
5.	Batch Compounding Equipment: General considerations, Two-roll mills, Internal mixers, Kneader, Continuous mixer, Tandem mixer, Banbury Mixer, New developments etc.
6.	Continuous Compounding Equipment: General considerations, General aspects of extruder compounding and extruder machine, Single screw extruder, Twin-screw extruder, Vacuum extruder, Transfer mix extruder, Gear extruder, HIM extruder, Barrier extruder, Zero pressure extruder etc., Miscellaneous continuous compounding machinery, General aspects of Injection compounding and Injection Molding machine and its process etc.
7.	Calendars: Types & sizes of typical machines, roll configurations, roll cambering, single trip & double rip arrangements for sheeting, equipments for coating of textile fabrics, friction coating, axis crossing devices, roll bending etc New developments.
8.	Molding & Casting : Molding, Review of Molding Methods, Compression Molding, Transfer

	Molding , Injection Molding, Materials handling & Mold Stripping, Mould lubricants, Surface treatments & Cleaning Deflashing & Finishing of Moldings, Blank preparation for moulding , Blank heating methods, injection moulding machine, types, screw & ram type machines, vertical injection moulding machines, ejection techniques, Blow moulding, Rotational moulding, New developments
9.	Vulcanization: Hydraulic and Hand Operated Press, Compression Moulding Machine, Autofoam and Bagomatic Press, Equipments for Volume by methods other than moulding, autoclave, curing methods, equipments for continuous vol. hot air tunnel, molten salt bath, fluidized bed, microwave curing etc.
10.	Other Processing Methods: Thermoforming, Foaming, Reinforcing, laminating, Spinning of Fibers and Mercerisation etc.

Reference Books:

1. Polymer Mixing Technology by George Mathews
2. Polymer Chemistry by B. K.SHARMA
3. Principles of Polymer Processing by Zethew Tadmor and Costas G. Gogos.
4. Rubber Technology & Manufacturing: by C. M. Blow
5. Rubber Engineering: IRI.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name Polymer Materials and Testing (Major Elective-3)

Sr.No	Course content
	Polymer Materials:
1.	Rubbers: Rubber Materials-Introduction, Natural Rubber, Synthetic Rubbers like SBR, PBR, Silicone, Butyl, NBR, Neoprene, EPDM, Floro Elastomers etc., Thermoplastics Elastomers, Rubber Compounding, Sulphur & Non-Sulphur Vulcanization, Assessment of Processibility and State of Cure, Hard Rubber or Ebonite, Latex Technology.
2.	Plastics: Plastics Materials-Introduction, Polyethylene, Linear Low Density Polyethylene, Polypropylene, Copolymers of Ethylene, Polystyrene, Acrylic Plastics, Poly(Vinyl Acetate, Vinyl Chloride), PTFE, CI Resins, Acetal Resins, Polyamides, Polyimides, Polyesters, Polyurethane, Polycarbonates,Epoxy Resins, Cellulose Plastics, Phenolic & Amino Resins, Silicones, Additives for Plastics.
3.	Fibers: Introduction, Natural Fibers, Semi Synthetic Fibers, Synthetic Fibers, Difference between Natural & Synthetic fibers, Important Requirements of a Fibre, Properties of Synthetic Fibres, Rayon or Artificial Silk, Polyamides, Polyethyleneterephthalate, Orlon, Polyvinyl Alcohol, Dacron, Saran, Vinyon, Teflon, Dynel, Fabric defects-definition and principal causes, Terminology used in fibre technology.
4.	Objective: To understand polymer testing related to short term as well as long term mechanical properties, thermal as well as electrical properties. To have in depth understanding of fundamental polymer processing operations.
5.	Introduction: Importance of Testing, Concept of Statistics, Quality Control, Standards and Standard Organizations, Preparations of test Samples and Conditioning.
6.	Identification, Testing&Evaluationof Rubbers & Plastics: Identification of Common Plastics and Rubbers, Physical Testing, Softening Temperature Tests, Melt Flow Index etc.
7.	Mechanical Properties: Short term and long term mechanical properties, their Significance and importance, Determination of Short term stress-strain properties such as Tensile strength, elongation at break, tensile modulus, compression,

	Flexural, Tear Resistance etc. Different types of Impact tests: Determination of impact tests for different polymeric materials, Study of creep, relaxation, set and fatigue, Hardness, Abrasion Resistance etc.
8.	Non destructive testing of finished and semifinshed products: Such as ultrasonic testing, acoustic emission or stress wave emission, radiography, optical methods, etc.
9.	Electrical Properties – Their importance and significance, effect of temperature and humidity on electric properties. Different types of electrical properties such as: Determination of dielectric strength, surface and volume resistance, Power factor and permittivity, Tracking resistance, arc resistance
10.	Thermal Properties: Determination of heat deflection temperature (HDT) Determination of vicat softening point VST) Determination of melting point and softening point for different polymers
11.	Environmental Resistance Properties Effect of liquids and chemicals, Study of weathering resistance, Study of weathering property, Study of fire resistance.
12.	Barrier Properties Their significance and importance, Study of Barrier properties.
13.	Analysis and Testing of Polymers: Chemical Analysis of Polymers, Spectroscopic Methods, X-Ray Diffraction Analysis, Optical Properties, Electronic Properties, Chemical Properties etc.

Experiments, Exercise and calculations based on above topics.

Reference Books:

1. Textbook of Polymer Science by FRED W. BILLMEYER
2. Handbook of Plastics Test Method, R.B. Brown, George Godwin Limited, 1981.
3. Polymer Science and Technology by Premamoy Ghosh, Second Edition.
4. Polymer Chemistry By b. K. Sharma
5. Polymer Science by P. L. Nayak.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1I
Chemical Engineering (CAPD)

Subject Name SEPARATION TECHNIQUES (Inter Disciplinary-2)

Sr.No	Course content
1.	Super Critical Extraction**: -** Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvent, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Decaffeination, ROSE process, extraction of aromatic from spice and other commercial application of supercritical extraction, Application under research.
2.	Short path Distillation:- Concept & working of short path Distillation Unit (SPDU), Difference between short part Distillation & molecular distillation, commercial application of SPDU, application research, Economics of short path distillation.
3.	Reactive & Catalytic Distillation: - Concept & and History, Advantage & Disadvantages, Various methods of applications: Process of MTBE, Process of ETBE and other commercial applications, BALE & KATMAX packing, etc, Effect of various parameters like reflux ratio, operating pressure, feed point location, etc.
4.	Pressure swing Adsorption:- Concept & Working, Advantage & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA
5.	Pressure swing distillation: Concept & Working, Advantage & Disadvantages of PSD over azeotropic and extractive distillation, industrial applications
6.	Melt Crystallization:- Concept, Different types of crystallization, phase equilibrium, different techniques used commercial applications.
7.	Membrane Separation Techniques: - i)Reverse Osmosis(R.O.) Concept of Osmosis & Reverse Osmosis , Different types of Membrane modules and membrane material used for R.O., Advantages & Disadvantages, and Commercial application of R.O. ii)Ultra filtration:- Concept & working principal, commercial application. iii)Pervaporization:- Working principal, Advantages & Disadvantages, Production of absolute alcohol and other commercial applications.

8.	Membrane Reactor:- Concept & working, various modules of membrane used for membrane reactor, Advantage & Disadvantages, application under research.
9.	Membrane of Osmotic Distillation: - Working Principal, Various application, etc.

Experiments, Exercise and calculations based on above topics.

Reference Books:

1. "Natural Extracts using supercritical carbon dioxide" M.Mukhopadhyay.
2. "Introduction to Process Engineering & Design" by S.B.Thakore & B.I.Bhatt.
3. 'Perry Chemical Engineers Handbook' 7thEdition by R.H.Perry and D.Green.
4. Ullman's Encyclopedia of Industrial Chemistry.
5. "Encyclopedia of Chemical Engineering " by Kirk & Othmer.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 1II
Chemical Engineering (CAPD)

Subject Name Polymer Structure and Properties Prediction (Major Elective –4)

Sr.No	Course content
1.	The Nature of Polymers: Polymers, Polymer Additives.
2.	Morphology and structuring of Polymers: Definition of Structuring, Polymer Single Crystal Morphology, Polymer Melt Crystallized Morphology, Effects of Crystallization Temperature, Effects of Crystallization Pressure, Strain and Flow- Induced Crystallization, Effects of Cold Drawing, Amorphous Polymers, Experimental Determination of Polymer Molecular Orientation.
3.	Surface Properties: Surface Tension, Adhesion, Tribology, Triboelectricity.
4.	The Relationship between Structure, Properties and Application.
5.	Submolecular Structure: Chemical Composition of the Polymer Molecule, Monomeric Ingredients in the Final Polymer Composition.
6.	Molecular Structure: Processibility, Mechanical Properties, Thermal Properties, Electrical Properties, Optical Properties, Chemical Properties, Balance of Properties
7.	Molecular Flexibility: Molecular Structure. Molecular Flexibility, Properties, Applications.
8.	Effect of Polymer Structure on Properties: Molecular Weight, Strength, Deformation, Physical state of Polymers, Elastic Property, Chemical resistance, Solubility, Intermolecular forces in monomers and polymers, Plastics-Elstomers & Fibers, Mechanical behavior of Polymers.
9.	Different Unit Structure of Polymers: Introduction, The causes of different unit structure of polymers, Amomalous groups, typical reactions of polymer chemical modification, the effect of unit structure on the properties of polymers.
10.	Polymer Structure and Physical Properties: The Crystalline Melting Point, The glass Transition, Properties Involving Large Deformation, Properties Involving small Deformation, Property Requirements and Polymer Utilization.
11.	Chemical Structure and Polymer morphology:

	Introduction, Molecular weight& intermolecular forces, The amorphous state-rheology, Glass Transition Temperature, Stereochemistry, Crystallinity, Chemical Crosslinking, Physical Crosslinking, Polymer blends.
12.	Morphology and Order in Crystalline Polymers: Configuration of Polymer Chains, Crystal Structures of Polymers, Morphology of Crystalline Polymers, Crystallization and Melting, Stain-Induced Morphology.
13.	Chemical Structure and Polymer Properties: Introduction, Fabrication methods, Mechanical Properties, Thermal Stability, Flammability and Flame Resistance, Chemical Resistance, Degradability Electrical Conductivity, Nonlinear Optical Properties, Additives.
14.	Rheology and the Mechanical Properties of Polymers: Viscous Flow, Kinetic Theory of Rubber Elasticity, Viscoelasticity, The Glassy State and the Glass Transition, The Mechanical Properties of Crystalline Polymers.

Reference Books:

1. Polymer Structure, Properties and Applications, by R.D. Deanin.
2. Principles of Polymer Processing by Zethew Tadmor and Costas G. Gogos.
3. Polymer Chemistry An Introduction by Malcolm P. Stevens.
4. Textbook of Polymer Science by Fred W. Billmeyer.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E SEMESTER: 1II
CHEMICAL ENGINEERING (CAPD)

Subject Name Computer Aided Product and Process Design(Major Elective – 4)

Sr.No	Course content
1.	Product and Process Design: Steps in Product and Process Design, Environment Protection, Safety Considerations, Engineering Ethics, Process Creation, preliminary database creation and process synthesis, development of base-case design, simulation to assist process creation, heuristics for process synthesis, Equipment Sizing and Costing.
2.	Design and Scheduling of Batch Processes: Single product batch plants, Multiple product batch plants, Transfer policies, Parallel units and intermediate storage, Sizing of vessels in batch plants, Inventories, Synthesis of flow shop plants
3.	Optimal design and scheduling of multi-product batch plants: Constraints for flow shop plants, MINLP design model for flow shop plants, MILP reformulation for discrete sizes, NLP design model-Mixed product campaigns, Cyclic scheduling in flow shop plants
4.	Geometric Techniques for the Synthesis of Reactor Networks: Graphical techniques for simple reacting system, Geometric concept for attainable regions, Reaction invariants and reactor network synthesis.
5.	Optimization Techniques for Reactor Network Synthesis: Reactor Network Synthesis with targeting formulation, Non-isothermal systems, Improvement to the targeting algorithm, Reactor Network Synthesis in process flow sheets, Energy integrating in reactor networks.
6.	Synthesis and Optimization of Distillation Sequences: Goal of system design, Minimum vapor flows, Marginal vapor flows, Liner model for sharp split columns, MILP model for distillation sequences, MILP model for continuous and discrete temperature, Design and synthesis with rigorous models.
7.	General concept of Simulation for Process Design: Introduction, Process Simulation Modes, methods for solving Non linear equations, recycle partitioning and tearing, simulation examples.
8.	Process Flow Sheet Optimization: Constrained non-linear programming, successive quadratic programming, process optimization with modular simulators, equation oriented process optimization.

Reference Books

1. Product and Process Design Principles
   Second Edition Warren D Seider, J. D. Seader, Daniel R Lewin
   Published by John Wiley and Sons,Inc.
2. Systematic Methods of Chemical Process Design
   Lorens T. Biegler , E.Ignacio grossmann, Arthur W Westerberg
   Published by-Prentice Hall International,Inc